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'LIVE' DYNAMIC TESTING OF THE F 2400-6 AND THE TYPE 19325 OXYGE--ETC(U)
JAN 79 D E HOLNESS, J A PORLIER, G R WRIGHT

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(6) "LIVE" DYNAMIC TESTING OF THE F 2400-6 AND THE TYPE 19325 OXYGEN PRESSURE REGULATORS.

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(10) D.E. Holness,
J.A.G. Porlier
G.R. Wright

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Defence and Civil Institute of Environmental Medicine
1133 Sheppard Avenue West, P.O. Box 2000
Downsview, Ontario M3M 3B9

DEPARTMENT OF NATIONAL DEFENCE - CANADA

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ABSTRACT

The performance of two oxygen pressure regulators used ~~regularly at the Defence and Civil Institute of Environmental Medicine~~ in hypobaric experimentation was evaluated ~~using~~ with a "live" dynamic testing technique. Human subjects imposed various levels of respiratory demands on the regulator systems by performing a variety of activities. Use of the Type 19325 regulator resulted in inspiratory and expiratory mask cavity pressures which were, in most instances, within acceptable limits. The F 2400-6 regulator tended to induce, to a greater extent, mask cavity pressures in excess of recommended limits. Consistently higher ($P<0.01$) peak and total respiratory flow rates were obtained when the Type 19325 regulator was used compared to those obtained when the F 2400-6 regulator was used. Based on these results of mask cavity pressures and respiratory flow rates, it was apparent that the F 2400-6 oxygen regulator imposed a greater impedance to breathing than the Type 19325 oxygen regulator.

less than

INTRODUCTION

Static or "steady" flow testing techniques have been traditionally used to evaluate the performance of aircraft oxygen systems. Although such techniques are still considered important, it is now recognized that final acceptance of an oxygen regulator system depends on results from dynamic testing (Zalesky and Holden, 1976 and Macmillan, 1976). "Live" dynamic testing is the most ideal technique for evaluating oxygen regulator systems; in such instances, the human serves as the experimental model and imposes a variety of pulsating respiratory demands on the oxygen system being evaluated.

The present study was undertaken to evaluate the performance of the F 2400-6 emergency oxygen regulator and the narrow panel Type 19325 oxygen pressure regulator using the "live" dynamic testing technique. Both of these regulators are employed extensively as components of the oxygen system in the hypobaric chamber complex at the Defence and Civil Institute of Environmental Medicine, Toronto, Canada.

MATERIALS AND METHODS

Seven young healthy males, of various levels of physical fitness, were voluntary subjects for this investigation.

A "slave mask" technique, as described by Macmillan (1976), was employed in order to measure the resistance to breathing imposed by the oxygen regulator systems. The experimental set-up is shown schematically in Figure 1. The subject was seated on a bicycle ergometer and breathed from a well-fitted oronasal mask (slave mask). This slave mask was connected in series via a flowmeter of low dead space, to a RAF P/Q mask which, in turn, was connected to either the F 2400-6 oxygen regulator (Aro Equipment Corporation, Bryan, Ohio) or the Type 19325 narrow panel oxygen pressure regulator (Aro Equipment Corporation, Bryan, Ohio). Performance characteristics of the F 2400-6 and the Type 19325 systems are shown in Table 1.

Each subject breathed from each system for five minutes in four states of physical activity:

a. Rest
b. Rest with speech
c. Light exercise
d. Light exercise with speech

In each of the above four states, subjects breathed air and 100 percent oxygen at ground level pressure and at normal ambient temperature.

Speech consisted of reading a standard page of literature at as normal a rate as possible. This activity imposed pronounced peak respiratory demands on the regulator systems. Exercise consisted of cycling on the bicycle ergometer at a 2 kp workload for five minutes.

Mask cavity pressure, during inspiration and expiration, was monitored continuously throughout each experiment with a pressure transducer (Statham PR 23-5G, range 0-300 mm Hg). Peak inspiratory and expiratory flows were measured by means of a flowmeter (Fliesch Pneumotachograph No. 3, Bionetics Ltd.); the peak flow signals were integrated by a Beckman preamplifier (Model 9878A) and resulted in recordings of total flow. A rotameter was used to calibrate the flowmeter. Respiratory gases (oxygen, nitrogen and carbon dioxide) were sampled from the P/Q mask with a heated cannula system and were fed to and analysed with a Medspect Medical Mass Spectrometer (Chemetron Ltd., St. Louis, Missouri).

All parameters monitored were recorded on a Beckman 8-channel ink pen recorder.

Statistical treatment of data was performed using the analysis of variance technique (ANOVA).

RESULTS

Changes in mask cavity pressure, averaged for the seven subjects for each category of activity are shown in Figure 2. When the F 2400-6 regulator was used, inspiratory and expiratory mask pressures differed significantly ($P<0.01$) from those when the Type 19325 regulator was used. The mask pressures were greater with the use of the F 2400-6 regulator than with the use of the Type 19325 regulator; they generally increased as the level of activity increased in the experiment and were largest when speech was conducted simultaneously with exercise. Consequently, total mask pressure swing was largest when the F 2400-6 regulator was used and also when exercise and speech were conducted simultaneously.

Averaged total gas flow rates, inspiratory and expiratory, increased as the level of activity increased in the experiment; exercise plus speech imposed the greatest flow demands (Figure 3). Consistently higher ($P<0.01$) total gas flows were obtained with the Type 19325 regulator than with the F 2400-6 regulator. During the exercise plus speech period, flow rates of 187 l/min and 141 l/min were observed during inspiration and expiration respectively, with use of the Type 19325 regulator; this compared with 124 and 74 l/min during inspiration and expiration respectively with the F 2400-6 regulator.

Consistently higher ($P<0.01$) mean peak inspiratory and expiratory flows were also obtained throughout the experimental phases when the Type 19325 oxygen regulator was used (125 and 100 l/min respectively) compared to those when the F 2400-6 regulator was used (99 and 80 l/min respectively) and are shown in Figure 4.

The relationship between mask pressure during inspiration and inspiratory flow rates, for both regulators, is shown in in Figure 5. As total and peak inspiratory flows increased, mask pressure decreased. A more pronounced mask pressure effect was observed with the use of the F 2400-6 regulator than with the use of the Type 19325 regulator.

The relationship between mask pressure and expiratory flow rates is shown in Figure 6. In general, as total and peak expiratory flow rates increased, mask pressure increased. However, when the F 2400-6 regulator was used, mask pressures were higher at lower expiratory flow rates (peak and total) than those when the Type 19325 regulator was used.

As anticipated, among the other parameters monitored in this experiment, end-tidal carbon dioxide tension (pCO_2), heart rate and respiration rate all increased during the exercise and exercise plus speech phases of the experiment. However, there were no significant differences in these parameters when either regulator was used.

DISCUSSION AND CONCLUSION

In the present study, use of the Type 19325 oxygen regulator resulted in inspired or minimum mask cavity pressures which were, in most instances, within recommended limits of mask cavity pressure, as outlined by Ernsting (1976). This conformity occurred when peak inspiratory flows were less than 110 litres per minute. Such flows were encountered in all phases of the experiment, except for that of exercise plus speech. Throughout the experimentation, the maximum mask cavity pressures during expiration did not exceed the recommended pressure limits by Ernsting (1976).

When the F 2400-6 regulator was used, minimum and maximum mask cavity pressures exceeded, in some instances, the limits of pressure recommended by Ernsting (1976). These excesses occurred particularly during the exercise and exercise plus speech phases of the experiment. The presence of a mask safety pressure (a positive pressure of 2 to 4 ins H_2O above ambient pressure in the mask) probably was implicated in this phenomenon of excessive mask cavity pressures. Excessive resistances to breathing were indicated at those experimental points when mask cavity pressures exceeded acceptable limits.

The total change of mask cavity pressure or the mask pressure swing during the respiratory cycle, with use of the Type 19325 oxygen regulator, was satisfactory throughout the experiment, except for the exercise plus speech category when peak inspiratory flows were greater than 110 litres per minute. When the F 2400-6 regulator was used, the mask pressure swing during exercise and the exercise plus speech phases of the experiment exceeded the limits of pressure recommended by Ernsting (1976). These results therefore imply increased resistances to breathing.

Based on the results of mask cavity pressures and respiratory flow rates, it is apparent that the F 2400-6 oxygen regulator imposed a greater impedance to breathing than the Type 19325 oxygen regulator, especially when respiratory demands were greatest. The sensations experienced by the subjects during the experiment concurred with this finding. The higher resistance to breathing probably is attributable to the presence of a safety pressure induced in the mask by the regulator; it apparently is an essential feature of an emergency type regulator, such as the F 2400-6, which assures good "get me down" capability from high altitudes.

REFERENCES

ERNSTING J. (1976) Physiological requirements for oxygen systems of high performance aircraft. ASCC Working Party 61, Vol. 2: 154-163.

MACMILLAN A. (1976) Physiological evaluation of oxygen systems. ASCC Working Party 61, Vol. 2: 230-242.

ZALESKY P. & HOLDEN R. (1976) Biomedical aspects of oxygen regulator performance: 1. Static Characteristics. Aviation, Space and Environmental Medicine 47: 485-494.

ACKNOWLEDGMENT

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TABLE 1

REGULATOR PERFORMANCE CHARACTERISTICS

AS DETERMINED BY STATIC TESTING*

F 2400-6 Oxygen pressure regulator

Inlet Pressure	43-95 PSI
Regulator to Mask Pressure	
- at 10 Litres/minute flow	+2.0-+4.0 INS. H_2O
- at zero flow	+2.5-+4.0 INS. H_2O
- at 90 litres/minute flow	-1.0-+1.0 INS. H_2O
Regulator to Mask Maximum Pressure	145mm Hg at 90 litres/min
Check valve flow	140 Litres/minute

Type 19325 Oxygen pressure regulator (narrow panel)

Operating Pressure Range	50-500 PSI
Internal Pressure Range	26- 50 PSI
Operating Altitude Range	
Air-Oxygen mixture	up to 32,000 ft
100% oxygen (Normal + Pressure Breathing)	- 43,000 ft
100% oxygen (Normal + Pressure Breathing- short time only)	- 50,000 ft

*Taken from Aro Equipment Corporation Manual (1972) - Oxygen Regulators.

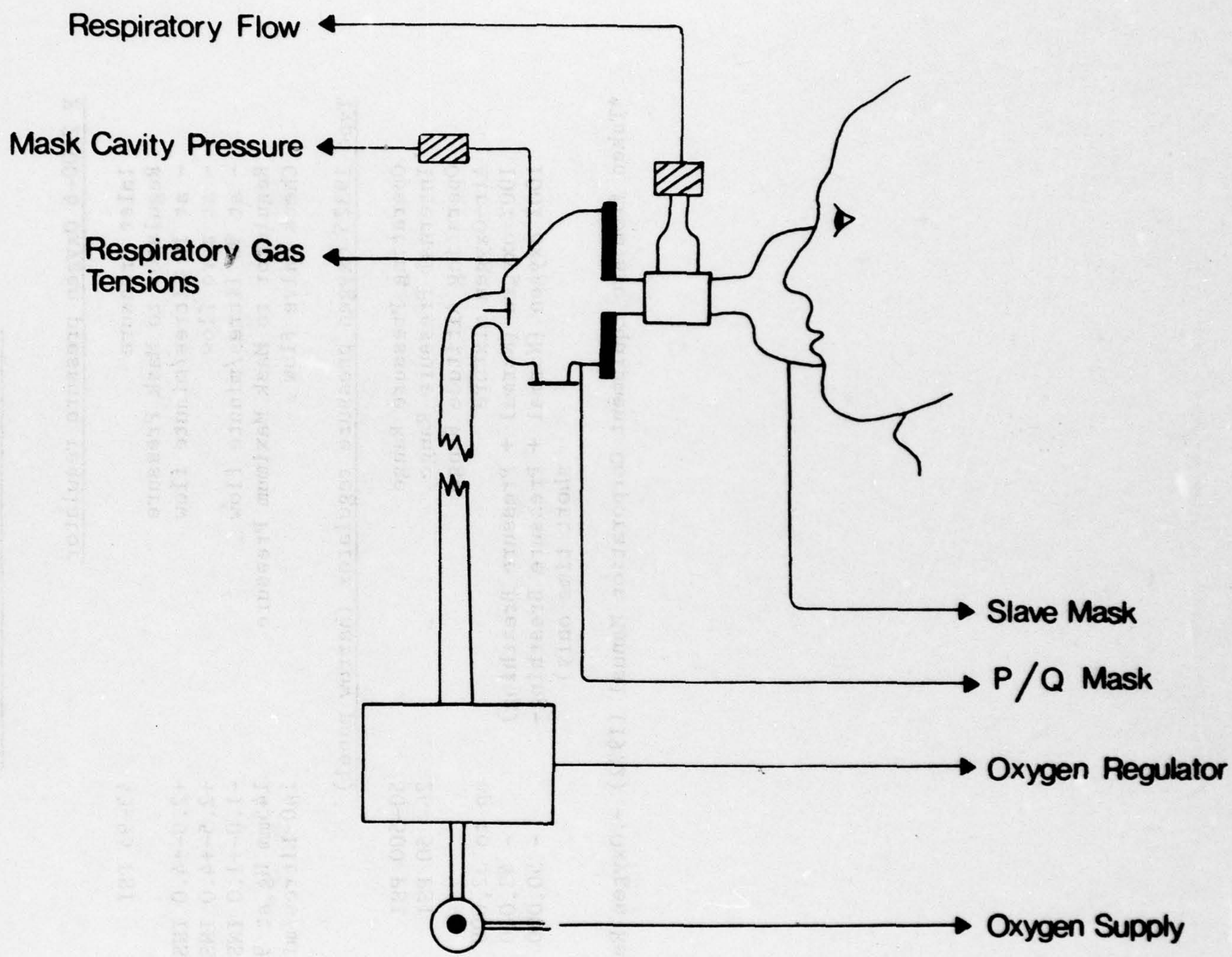
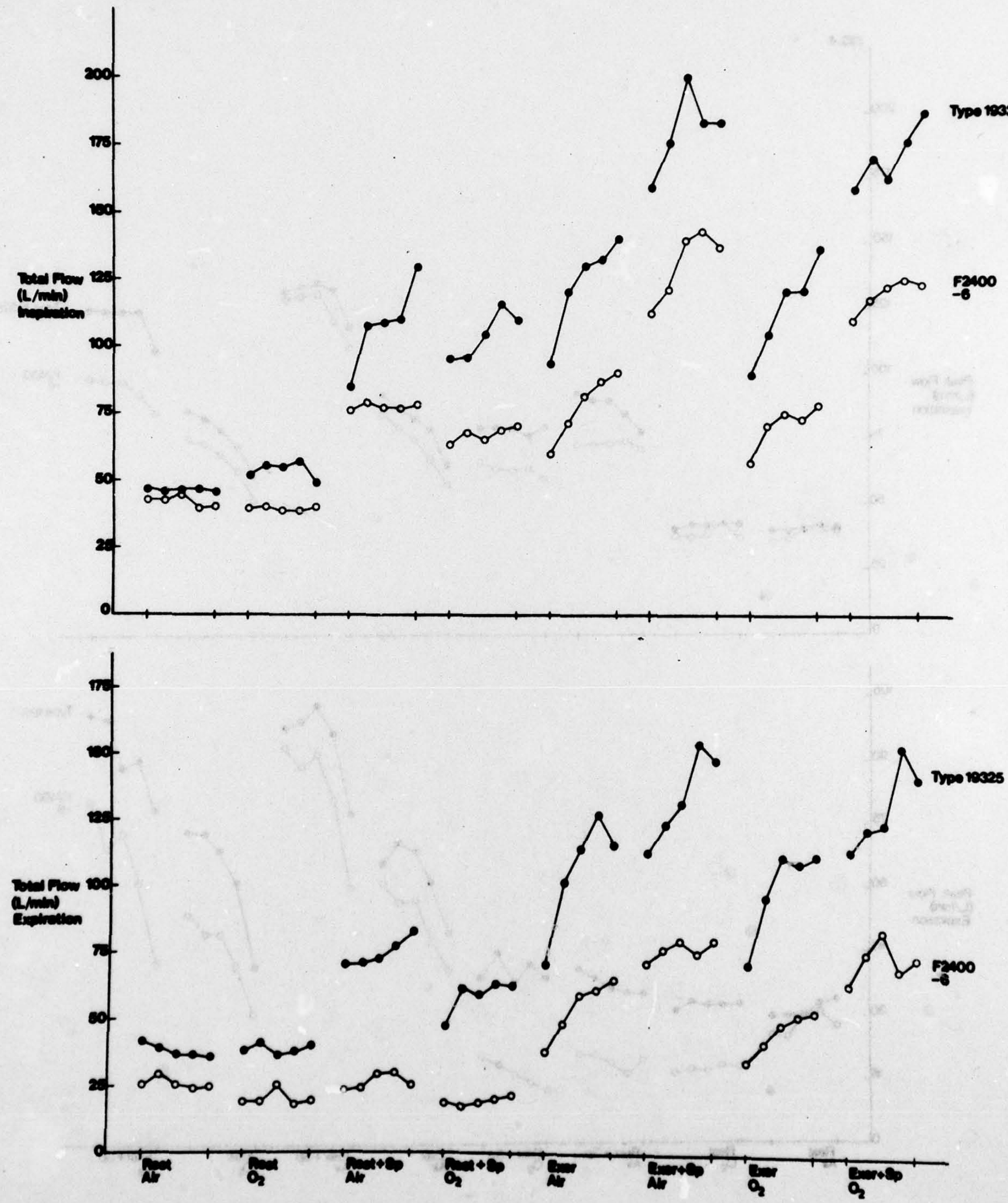


Fig.1 'Slave Mask' Assembly For Measuring Breathing Resistance

FIG.3



Total Flow (L/min) Inspiration
0
25
50
75
100
125
150
175
200
Type 19325
F2400 -6
Total Flow (L/min) Expiration
0
25
50
75
100
125
150
175
Type 19325
F2400 -6
Rest Air
Rest O₂
Rest+Sp Air
Rest+Sp O₂
Exer Air
Exer+Sp Air
Exer O₂
Exer+Sp O₂

FIG.4

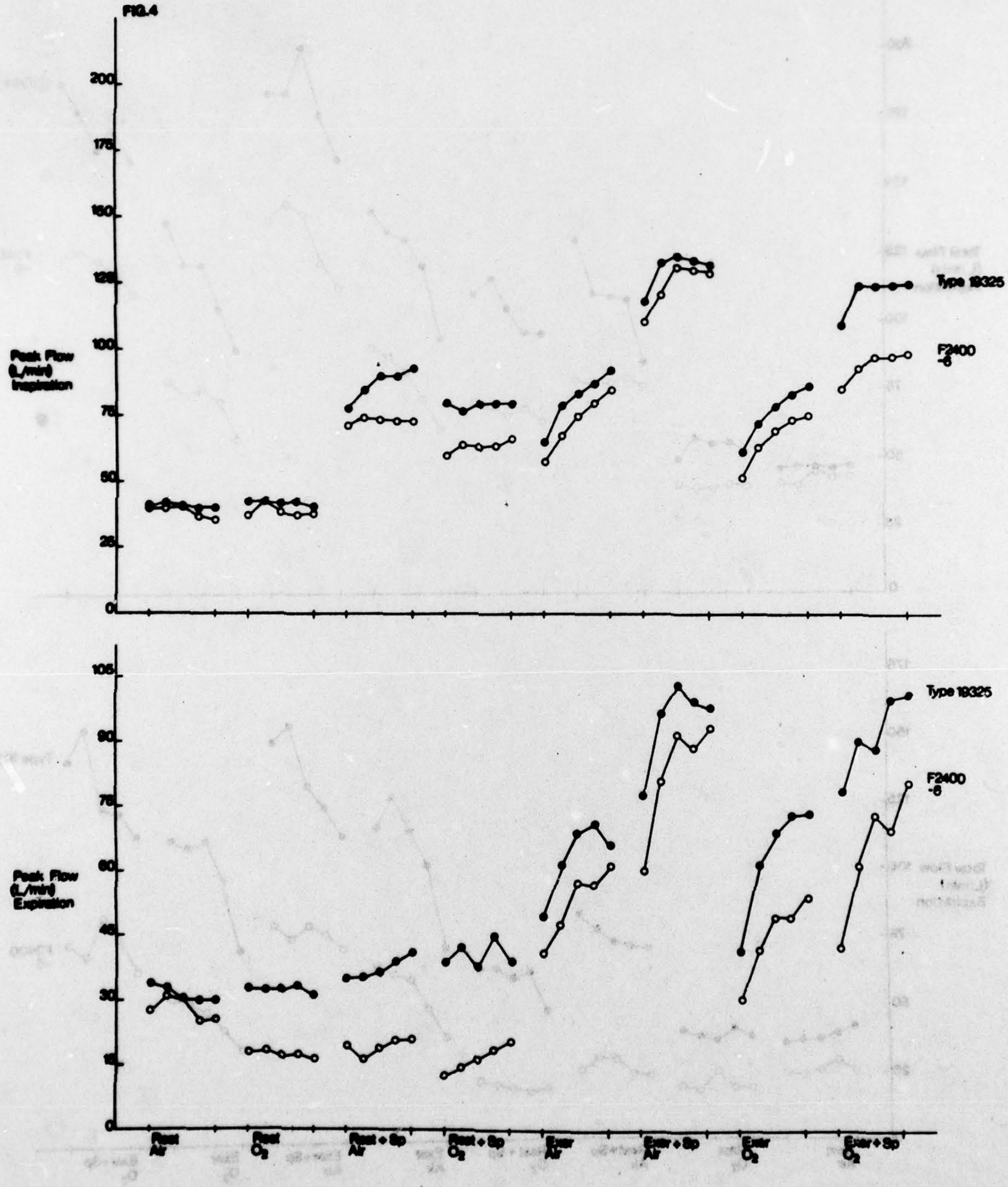
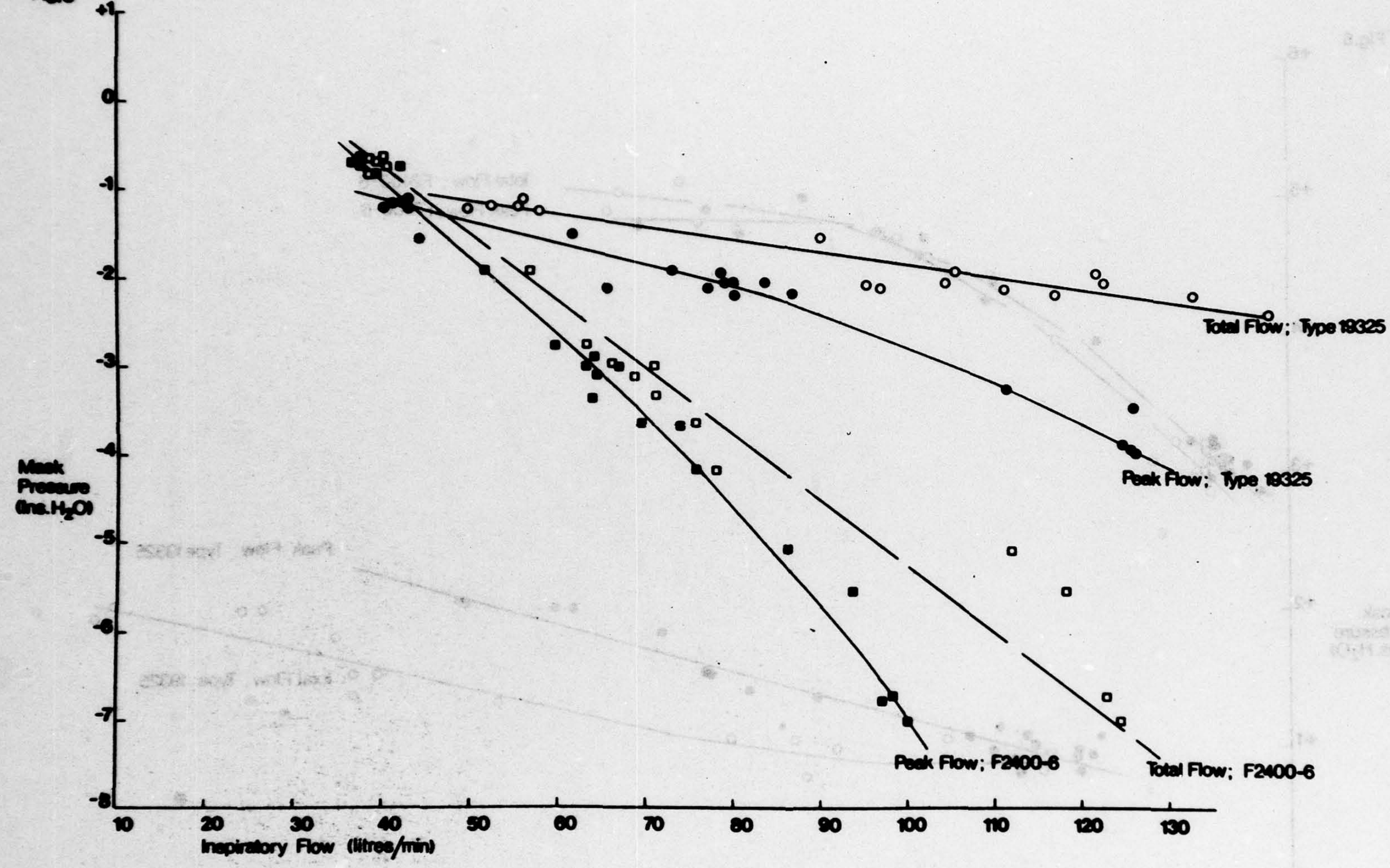

200
175
150
125
100
75
50
25
0
Peak Flow
(L/min)
Inspiration
Type 19325
F2400
-6
105
90
75
60
45
30
15
0
Peak Flow
(L/min)
Expiration
Type 19325
F2400
-6
Rest
Air
Rest
O_2
Rest + Sp
Air
Rest + Sp
O_2
Exer
Air
Exer + Sp
Air
Exer
O_2
Exer + Sp
O_2

Fig.5


Mask Pressure (ins.H$_2$O)
+1
0
-1
-2
-3
-4
-5
-6
-7
-8
Inspiratory Flow (litres/min)
10
20
30
40
50
60
70
80
90
100
110
120
130
Total Flow ; Type 19325
Peak Flow ; Type 19325
Total Flow ; F2400-6
Peak Flow ; F2400-6

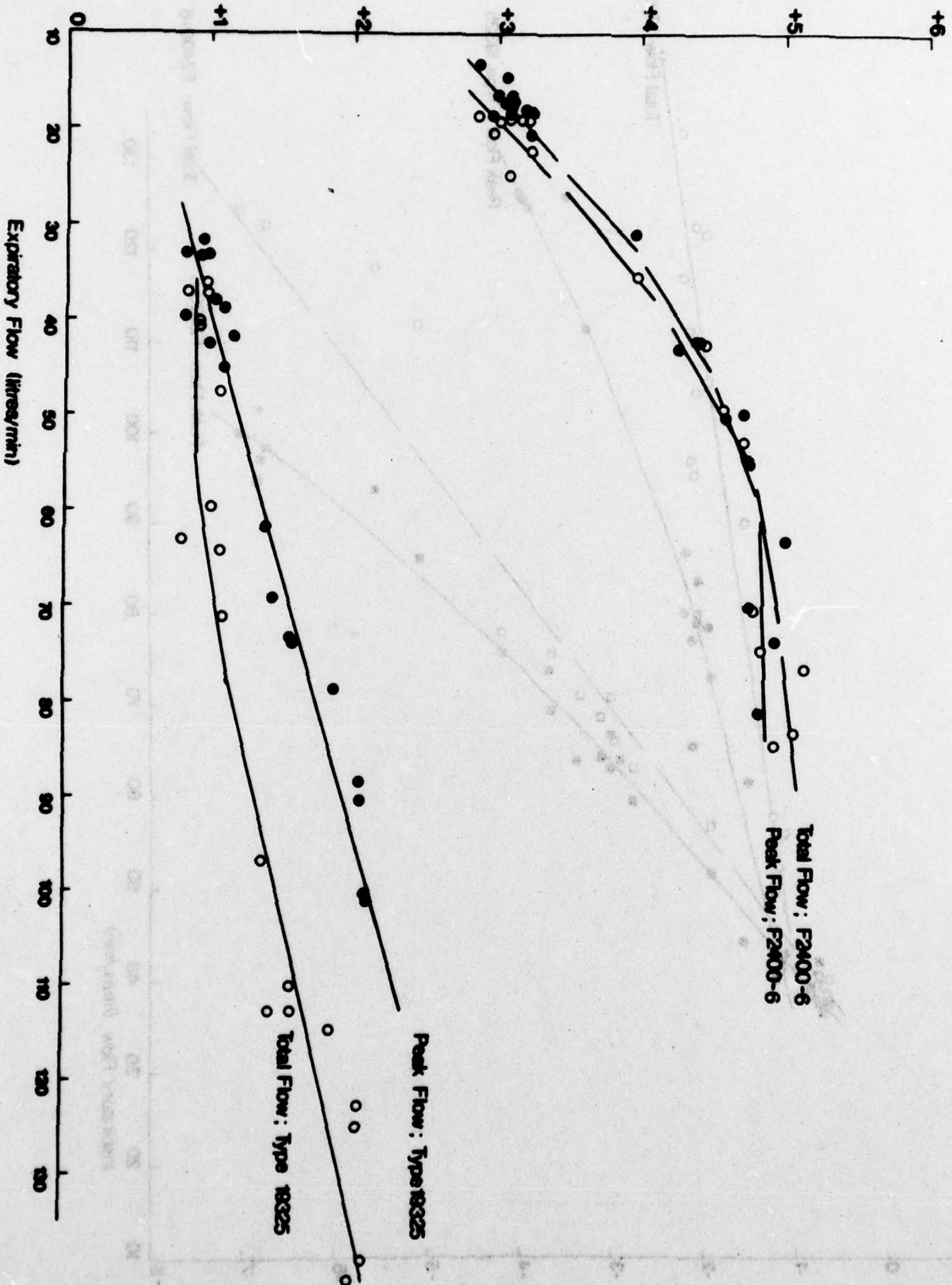
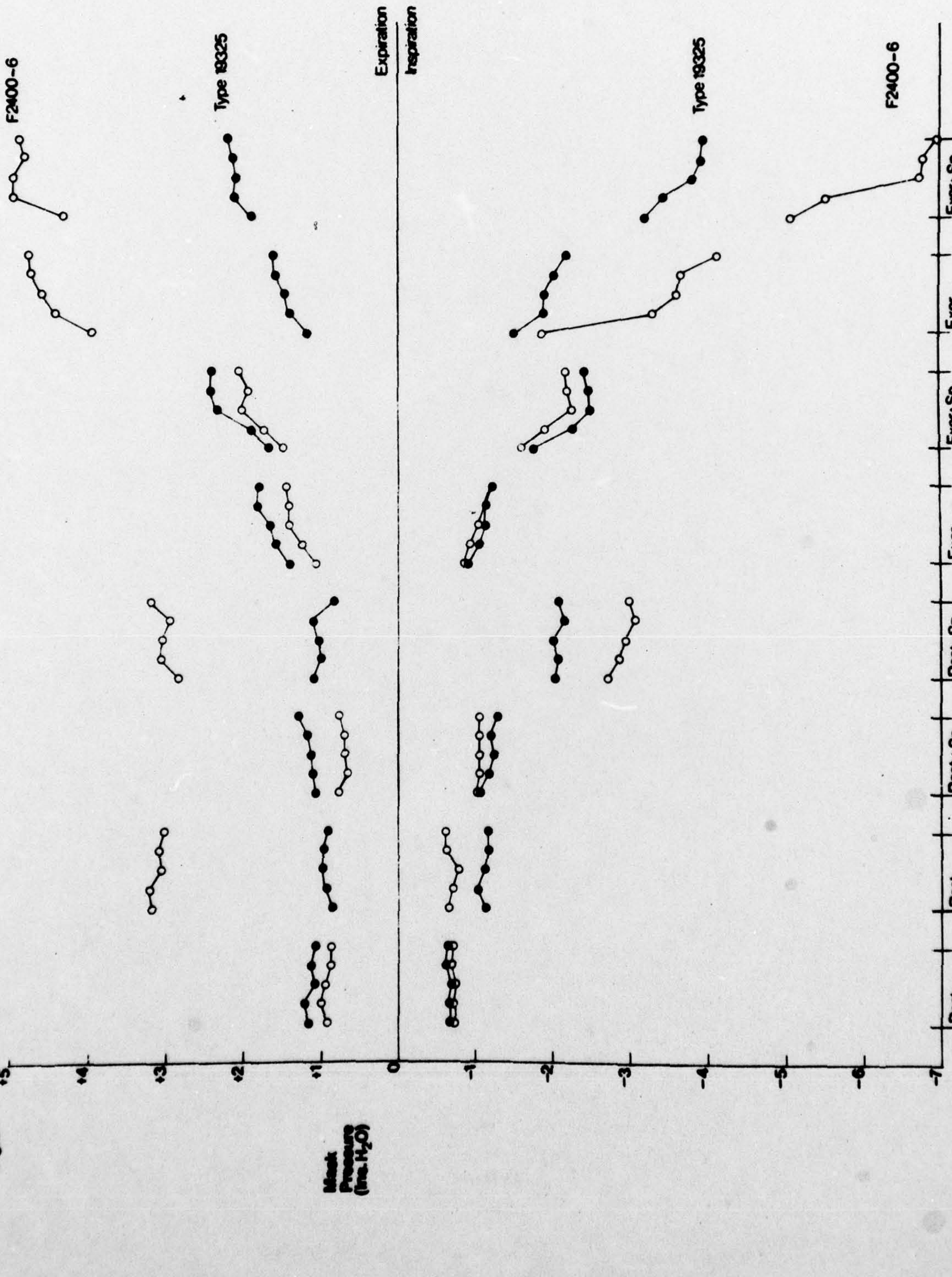

Mask Pressure (ins. H_2O)
0
+1
+2
+3
+4
+5
+6
10
20
30
40
50
60
70
80
90
100
110
120
130
Expiratory Flow (litres/min)
Total Flow ; F2400-6
Peak Flow ; F2400-6
Peak Flow ; Type 18325
Total Flow ; Type 18325

Fig.6

Fig.2


Mask Pressure (Ins. H_2O)
+5
+4
+3
+2
+1
0
-1
-2
-3
-4
-5
-6
-7
Expiration
Inspiration
F2400-6
Type 19325
Type 19325
F2400-6
Rest Air
Rest O_2
Rest+Sp Air
Rest+Sp O_2
Exer Air
Exer+Sp Air
Exer O_2
Exer+Sp O_2